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Indian Standard

METHOD OF TEST FOR DETERMINATION OF THERMAL ENDURANCE OF INSULATING VARNISHES

PART 3 BOND STRENGTH BY HELICAL COIL METHOD

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Indian Standard

METHOD OF TEST FOR DETERMINATION OF THERMAL ENDURANCE OF INSULATING VARNISHES

PART 3 BOND STRENGTH BY HELICAL COIL METHOD

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Indian Standard

METHOD OF TEST FOR DETERMINATION OF THERMAL ENDURANCE OF INSULATING VARNISHES

PART 3 BOND STRENGTH BY HELICAL COIL METHOD

0. FOREWORD

0.1 This Indian Standard (Part 3) was adopted by the Indian Standards Institution on 30 January 1985, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard deals with the determination of thermal endurance of insulating varnishes by three different methods covered in a series comprising the following three parts:

Part 1 Electric strength method,
Part 2 Measurement of loss of mass, and
Part 3 Bond strength by helical coil method.

0.3 This standard (Part 3) covers the method of determining relative thermal endurance of insulating varnishes by measuring bond strength by helical coil method.

0.4 In preparing this standard, assistance has been derived from IEC 290 (1969) Evaluation of the thermal endurance of electrical insulating varnishes by the helical coil bond test issued by the International Electrotechnical Commission.

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1. SCOPE

1.1 This standard (Part 3) covers a method for determining the thermal endurance of insulating varnishes by evaluating the bond strength of a thin film of insulating varnish on a helical coil by measuring the changes in the strength of dried film of varnish as affected by ageing at elevated temperature.

2. SIGNIFICANCE

2.1 In this test 1 mm diameter aluminium wire in the form of a helical coil is coated with varnish and dried/cured. The force necessary to break this coil as a simple beam is a measure of the varnish film strength.

3. TEST SPECIMEN

3.1 Wire — Aluminium wire used for this method shall be an uncoated, smooth and annealed wire of 1·0 mm. Aluminium wire is recommended for high temperature varnish film evaluation test, because the aluminium oxide resulting from high temperature curing or ageing bonds tenaciously to the wire and has little effect on the test results. Where varnish adhesion and compatibility are of interest, the coils may be made using wires of metals other than aluminium and note made in the report of the metal used.

3.2 Preparation of Coil

3.2.1 The helical coils shall be formed by winding the wire without gaps between adjacent turns on a 6·3 mm diameter mandrel. The coil shall be formed using a suitable mechanical system and applying tension by a load of 10 N to the wire in order that the turns fit exactly to the mandrel.

3.2.2 The coils may be in a long continuous length and then cut off to a length of 75 mm. The wire ends of each coil shall be twisted to form a loop (*see* Fig. 1).

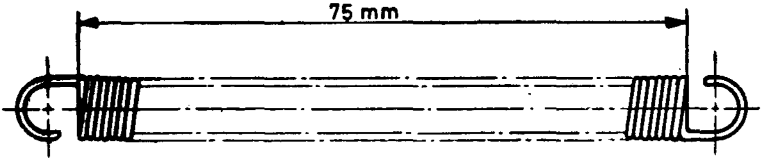

FIG. 1 HELICAL COIL TEST SPECIMENS

3.2.3 The coils shall be cleaned by immersing them in a clean solvent (toluene-alcohol mixture or similar solution). They shall be removed, rinsed once or twice in acetone and then dried.

3.3 Number of Specimens — A minimum of five coils shall be used for each test cycle. For each ageing temperature more than 60 coils will be required.

3.4 Varnish Dipping and Curing — The consistency of the varnish to be tested shall be so adjusted by trial that two coats on a specimen of the wire used for coils gives a film of dry varnish of 0·05 ± 0·005 mm in thickness. In cases where it is impossible to obtain a 0·05 mm thickness, tests may be carried out with a different coating thickness and this is noted in the report. After each dip, the specimens shall be dried/cured and reversed endwise between subsequent dips. The specimens shall be varnished and dried cured at the temperature and time specified by the varnish manufacturer.

4. TEST APPARATUS

4.1 Testing Machine — Any universal tensile machine accurate to 2 percent of the lowest load may be used. The arrangement for applying load to test specimen shall be motor driven to ensure constant rate of elongation.

4.2 Ageing Ovens — The air circulating ovens shall be such that the temperature inside the oven does not vary by more than ±2°C from the specified temperature.

5. AGEING TEMPERATURE AND TIME

5.1 The specimens shall be aged at not less than three, and preferably more, ageing temperatures covering sufficient temperature range to establish the relative thermal endurance. The ageing temperatures shall differ by at least 20°C. The lowest ageing temperature shall give a tested thermal life of at least 5 000 hours.

An ageing temperature giving a thermal life of less than 100 hours shall not be used.

To reduce the error in extra-polating thermal endurance data and to obtain the temperature index, the lowest ageing temperature should be chosen so that an extra-polation exceeding 20°C should not be necessary.

Choose the exposure temperature so that any essentially linear portion of the life data curve (log of time to failure versus the reciprocal of the absolute temperature) is well established.

For suitable exposure temperature ranges and cycle durations, please refer Table 1 of IS : 8504 (Part 1) - 1977*.

6. DETERMINATION OF BOND STRENGTH

6.1 Test Procedure — The specimen shall be placed in a testing fixture assembled in a suitable tensile tester. The spacing between the two supporting elements of the fixture shall be 44 mm and the breaking element shall contact the test specimen midway between the supporting elements. An example of one design of testing fixture is shown in Fig. 2. An increasing force shall be applied to the specimen till it breaks. The force necessary to break the coil shall be recorded.

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*Guide for determination of thermal endurance properties of electrical insulating materials : Part 1 Temperature indices and thermal endurance profiles.

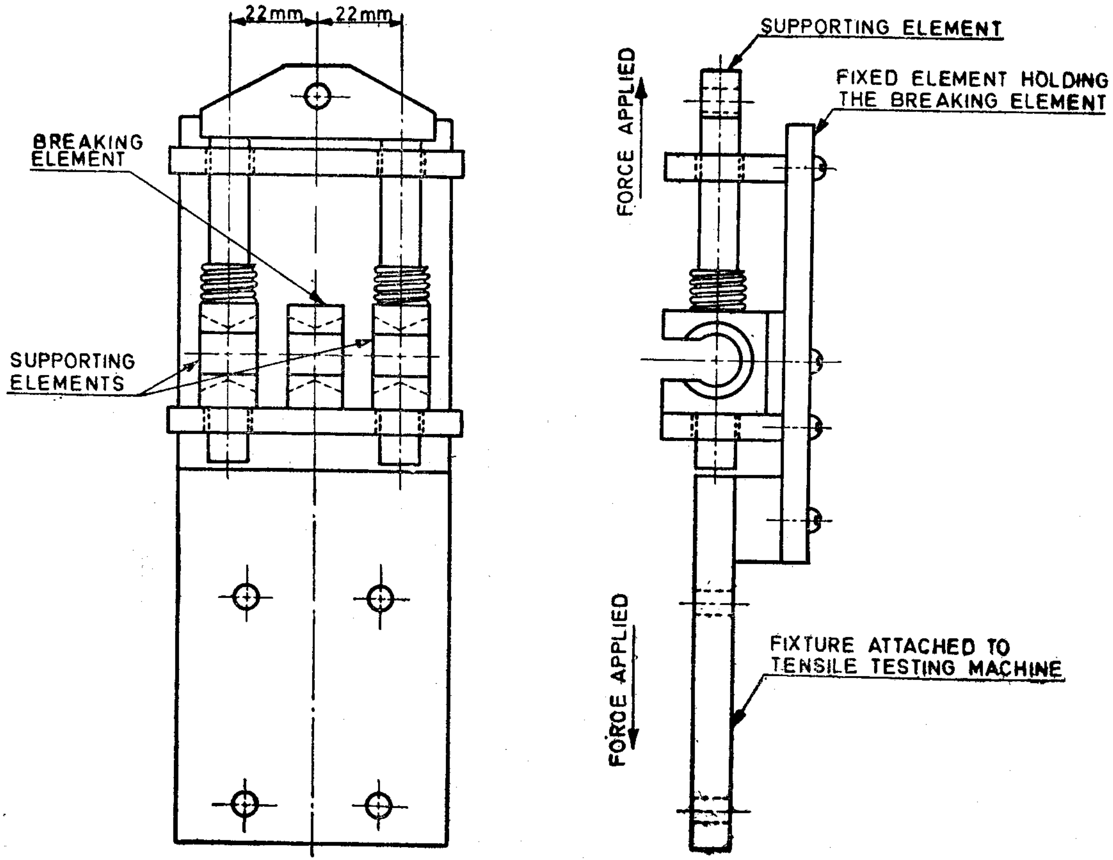

FIG. 2 EXAMPLE OF VARNISH BOND STRENGTH TEST FIXTURE

6.2 Rate of Extension — Since most varnishes have a low elongation, provision must be made to allow time to register the value of breaking force. If the test machine has a constant rate of elongation, more reliable measurements may be obtained by inserting tension springs between the movable element of the testing fixture and the movable element of the tensile tester. The rate of elongation shall then be 5 cm/min.

6.3 Ageing and Specimen Testing — The specimens shall be suspended vertically in the ageing oven and placed to allow free movement of air around each specimen and to avoid vibration that might damage them. Since some varnishes may soften at high temperature, the specimens shall not touch each other. The specimens shall not be laid in trays or other containers which might cause a distortion of the varnish film.

The specimens shall be removed at the end of each ageing cycle and conditioned for at least 4 hours at 27 ± 2°C at standard atmospheric conditions (*see* IS : 2260-1973*) and then tested for the bond strength.

A minimum of five coils shall be used for each test.

The average bond strength is obtained by averaging the five values.

An unusually low value of the bond strength may result from mishandling during testing; a fault in the varnish film or a failure of the testing equipment. Therefore, if a value of the bond strength deviates by more than 50 percent from the average value recorded for the set of five coils, it may be discarded and a sixth coil may be tested to complete the set of five.

7. BOND STRENGTH END POINT

7.1 22 N is recommended as the end point criterion for bond strength by helical coil method.

7.2 When agreed upon other end points may also be used.

8. EVALUATION OF TEST DATA

8.0 Complete evaluation of detailed test data comprises of the following.

8.1 Determination of time to reach the end point criterion at each ageing temperature. This is carried out as per **11.2** of IS : 8504 (Part 1)-1977†.

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*Specification for preconditioning, conditioning and testing of solid electrical insulating materials (*first revision*).

†Guide for determination of thermal endurance properties of electrical insulating materials: Part 1 Temperature indices and thermal endurance profiles.

8.2 Determination of thermal endurance graph. This is done as per **11.3** of IS : 8504 (Part 1)-1977*.

8.3 Determination of temperature index or of the thermal endurance profile as per **11.4** of IS: 8504 (Part 1)-1977*.

9. CALCULATION

9.1 Details of statistical methods for determination of thermal endurance profile (TEP) are to be followed as given in Part 3 of IS : 8504† (*under preparation*).

9.2 Calculation of thermal endurance profile (TEP) and examples are given in Part 4 and Part 5 of IS : 8504† (*under preparation*).

10. REPORT

10.1 The test report should incorporate the following information:

a) The description and identification of the varnish used along with its type, physical properties, the manufacturer, etc;

b) The description of wire including type of metal used in preparing the coil and its diameter;

c) Special treatment of samples, if any. Number of dips necessary to obtain proper build;

d) Drying/curing time and temperature used to prepare specimens;

e) The end point selected;

f) A graph of relative thermal endurance on a logarithmic time scale as a function of the reciprocal of the absolute temperature;

g) Thermal life at 20°C above the temperature index or the lowest ageing temperature; and

h) The temperature index corresponding to an extra-polated life of 20 000 hours.

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*Guide for determination of thermal endurance properties of electrical insulating materials: Part 1 Temperature indices and thermal endurance profiles.

†Guide for determination of thermal endurance properties of electrical insulating materials.